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A Study in the Transfer of Training, with Especial Reference to the Factors of Speed and Accuracy

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A STUDY IN THE TRANSFER OF TRAINING, WITH ESPECIAL REFERENCE TO THE FACTORS OF SPEED AND ACCURACY

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BY

CLAUDE EMANUEL BURGENER

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THESIS

Submitted in Partial Fulfillment of the Requirements for the

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IN

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I HEREBY RECOMMEND THAT THE THESIS PREPARED UNDER MY SUPERVISION BY

Claude Emanuel Burgener

ENTITLED A Study in the Transfer of Training, With Especial Reference to the Factors of Speed and Accuracy.

BE ACCEPTED AS FULFILLING THIS PART OF THE REQUIREMENTS FOR THE

DEGREE OF Master of Arts in Psychology.

S. S. Colvin In Charge of Major Work

S. S. Colvin Head of Department

Recommendation concurred in:

Committee
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Final Examination

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The change in late years of the viewpoint of psychology in regard to the nature of mental activities has reversed many of the old ideas concerning the "transfer of training" and "formal discipline". Owing to the pedagogical significance of the question as to the possibility of transfer much experimental work has been done in certain lines to determine whether or not transfer of training from one set of activities to another set is possible, and if so what is the extent and nature of the transfer. The work already done has established pretty clearly that, "practice effects may be, and generally are, transferred from one set of activities to another". At present the question is not so much on the fact of transfer but a question of the factors involved in this transfer.

The literature of the experimental work has been repeatedly reviewed so that it is unnecessary here to discuss it in detail. Some of the more important facts will be touched upon, however, particularly in their connection with the present investigation.

The experimental investigations to date have dealt in general with transfer of training (1) in memory (James, Fracker, Winch, Ebert, and Meumann); (2) in judgment (Thorndike and Woodworth, Bair, Judd, Coover and Angell, Volkmann, Urbantschish, Epstein, and Vogt); (3) in muscular strength and control (Scripture and Davis); and (4) in neatness (Ruediger and Bagley).

The general method of procedure in all the experimental

work is very similar. A test series is first given the reagent to determine his ability in a certain activity at the outset. Next the reagent is given training in some activity that resembles to a greater or less extent the activity of the first test series. During this practice period, of course, the test series is suspended. After the period of training, the initial test series is repeated. A comparison of the initial test series with that of the final test series is made to determine the extent of transfer from the practice series.

James[1] was really the pioneer in experimental work in this field. In his method he learned for the initial test series 158 lines of Victor Hugo's "Satyr" each day for eight successive days. Then for the training series, he learned the entire first book of "Paradise Lost", by working "twenty-odd minutes each day" for thirty-eight days. For the final test series he learned 158 additional lines of Hugo's "Satyr".

Fracker's[2] experiment was with eight reagents in the training group and four in the control group. For the test series he included (a) memory for poetry, (b) memory for the order of four shades of gray, (c) memory for the order of nine tones, (d) memory for the order of nine shades of gray, (e) memory for the order of four tones, (f) memory for the order of nine geometrical figures, (g) memory for the order of nine numbers, (h) memory for the extent of arm movement. For the training series, he practiced the reagents in memorizing the order of nine

[1] - Psychology (James), Vol. I, p. 667.
[2] - Psy. Rev. Monograph Supplements, 9: No.2, pp.56-102.

tones. The first test series was repeated for the final test. Fracker also used a "control" group. That is, he gave an equal number of reagents the test series without the training series. All other conditions were the same. The comparison of the results obtained from the "control" group gave an efficient check on the results obtained from the practice group.

Winch[1] tested upwards of 100 school girls from eleven to fifteen years in age, comprising standards VI and VII forming the first class of a London elementary school for girls. He gave as the initial test the memorization of prose selections. The same definite length of time was allowed for each selection. He divided the girls into two groups, one the "control", the other the practice or training group. The latter were given training in memorizing poetry. The control group was given no training. At the end of the training period both groups were again given the test in memorizing prose..

Winch later conducted two further experiments employing a similar method.

In a later experiment[2] with 113 school children, Winch used as an initial test series, "several tests in problematical arithmetic". On the basis of these tests he divided the children into two groups, equal in ability for arithmetical reasoning. One group was then "practiced in a series of exercises in rule sums which every child knew how to do; the other group being meanwhile engaged in some other branch of school work". After

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1 -British Journal Of Psychology, 2:284.
2 - Jr. Ed. Psy. 1:561, Dec. '10.

this training, "the two groups, the one practiced in accurate numerical computation, and the other not so practiced, were placed together again and final tests were given in arithmetical reasoning".

In another yet later experiment[1], Winch uses the same general method.

Ebert and Meumann[2] used as the initial and final test series, nonsense syllables, numbers, letters, one-syllabled substantives, Italian words, poetic words, and visual signs, which their subjects memorized. The training series consisted in the memorization of nonsense syllables. No "control" test was employed.

The general method used in the tests for the transfer of training in judgment was similar to those just given for testing the transfer of training in memory.

As a test series, Thorndike and Woodworth[3] determined the subject's ability to estimate correctly certain magnitudes, e.g. lengths of lines. For the training series the subject was practiced in estimating lengths within certain limits until he attained a high degree of proficiency. After this training the subject was given again the preliminary test series. The number of subjects in these experiments was six.

In another experiment[4], Thorndike and Woodworth state their general method as here given. "The subject would, for instance, practice marking every word containing the two letters e and s until he attained a considerable improvement in speed

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1 - Jr. Ed. Psy. 2: May 1911.
2 - Archives fur die gesamte Psychologie, Vol. IV.
3 - Psy. Rev. 8:247-261; 384-395.
4 - Psy. Rev. 8:553-564.

and possibly in accuracy as well". This was the training series. The following constitutes the initial and final test series. "Before and after this training, he would be tested in marking words containing other combinations of letters, misspelled words, a certain letter printed promiscuously amongst others, words of a certain length, different parts of speech, etc." Five reagents were employed in these tests. Later, eight reagents were tested as a "control" group.

Coover and Angell[1] used as a test series for four reagents the ability to discriminate shades of gray. Each test consisted of three series delivered on three separate days. Each series required thirty-five judgments. The training series was one in ability to discriminate different intensities of sound.

The experiment carried on by Miss Smith[2] under the direction of Scripture consisted of a test series in which the subject attempted to thrust a needle thru a hole without permitting the needle to touch the sides of the hole. Twenty trials were made with the left hand, and the same number of trials with the right hand. The right hand was then further trained for ten days, 200 trials being made each day. At the end of this period of training, the left hand was retested. Only one reagent, Miss Smith, tried this experiment.

Another experiment[3] was carried on by Miss Brown under Scripture's direction. The initial and final test series for muscular strength consisted in pressing, as strongly as possible,

1 - Amer. Jr. Psy., Vol. 18:328-340.
2 - Studies from the Yale Psychological Laboratory, Vol.2:114-119
3 - Ibid.

the bulb of a mercury dynamometer with the left hand. This was repeated ten times with an interval of about one minute between each effort. For the training series, the right hand was given practice in the same way except that it was continued for ten days.

These general descriptions of various methods used are typical of what has already been done. Results have been worked out with regard to transfer of training in memory, judgment, and Ruediger[1] and Bagley[2] have worked out experiments as to the possibility of the transfer of training in neatness.

These experiments which indicate the general character of the work done thus far have been aimed at the problem of the transfer of training in memory, in judgment, as for example in the estimation of magnitudes or in the discrimination of colors, in muscular strength and control, in neatness, in ability to mark words containing certain vowels or combinations of vowels, and in arithmetical reasoning.

In most of them only a few, or at least relatively few, subjects have been tested. The experiment to be reported in this paper is similar to the experiments just cited in so far as the method includes an identical initial and final test series, a training series, and a division of the reagents into a "control" group and a "training" group. In a number of experiments cited, no control test was employed. This is true of all of the earlier experiments, including those of Thorndike and of Ebert and Meumann.

[1] - Improvement of mental functions thru ideals.
[2] - Bagley, "The Educative Process", Chap. 13, p.208.

But our experiment differs from these others, first, in the very much greater number of reagents tested, and second, in the character of the factors of transfer chosen for investigation. The complete experiment carried on with about 1700 school children of the grades one to eight inclusive was aimed to determine the effect of practice in one set of activities on the ability to perform another set of related activities with especial reference to the factors of speed and accuracy.

The public schools offered the best opportunity for such a study, and to them the experiment was taken. The first two tests described in this paper were carried on in the model school of the Eastern Illinois State Normal School at Charleston; the third in five ward schools of Bloomington, Illinois.

In two of the tests employed in the investigation under discussion, the activity investigated in the first and in the final test-series was that of inscribing in specially ruled squares certain geometrical figures, while in the practice series the letter X was written, with the exception of the test in one school in which the order of the procedure was reversed. In the remaining test (Test II) the test-series consisted in marking out capital As, and the practice series in marking out other capitals. These tests will be described in detail in their appropriate place.

In handling the data of these tests, the speed was reckoned directly by the number of figures made or letters marked out by each pupil. To classify the papers for accuracy, six

grades of excellence were established, and the papers were graded accordingly one, two, three, four, five or six, as they corresponded respectively to those standards of excellence. One was the lowest grade given, while six was the highest. In test III, ten grades of excellence were established instead of six, as this permitted more accurate classification. To classify the papers, this method of comparison was used. Sheets representing the standards of excellence were selected. Then the other sheets were placed in piles as they matched respectively the standard sheets. The mathematical computations[#] were made according to the method of the mean or average[1] $A = \frac{(V\ f)}{n}$ and the probable[2] error $= 0{,}6745 \frac{}{n}$.

In test II the same method of computation was employed and the same method for determining speed and accuracy as in test III. But the grading for accuracy was of necessity much more difficult. Here each sheet was carefully examined to see how accurately each capital marked had been struck thru the center. Altho great care was exercised, the grading for accuracy was most difficult and even unsatisfactory. This resulted from the smallness of the letters, the variation in the width of the pencil marks, the different slanting of the marks made by the various pupils, the great number of marked capitals on each sheet, and, owing to the imperfect motor control of children, the wide variation, even in the same sheet, of accuracy in marking. Attention will be called to this matter later in

- The computations of test I were made by C. A. Barnhart, Assistant in Mathematics of the University of Illinois.
1 - C. B. Davenport, Statistical Methods, p.13.
2 - Ibid, p.15.

the discussion of the results of Test II.

TEST NO. 1.

This test was made with the children, about 200 in number in the model school of the Illinois State Normal School at Charleston. These children composed the entire eight grades of the practice school. The first test series was given to all the children for five minutes each day, for five consecutive days. This test was to make rapidly and accurately figure I (see appendix, note 1) in each square of a sheet 8 1/2" by 11", and ruled two squares to the inch. The length of time for the test was carefully observed, the pupils starting and stopping immediately upon a given signal. After the exercise was completed, the papers were collected and at the next test a fresh sheet was supplied to each pupil. Uniformity of conditions was also observed as far as possible. Pencils were freshly sharpened before each test. The test itself was repeated at the same hour each day, and at a time when there would be the least possibility of distraction. For example, care was taken not to place the test just before or after intermission when the pupils would likely be restless or indifferent. A full statement of the directions exactly as given is reproduced in the appendix, note 2. After this initial test, the pupils were divided into two equal numerical groups having as near as possible the same number of boys and girls in the corresponding groups. One group was then given training in the practice of making the five figures 2, 3, 4, 5, and 6. (See appendix, note 1.) A different figure was used each successive day and the series repeated in

the same order each week for five weeks. The order used is that as given in the appendix. Other conditions were maintained as in the initial test series. The second group was not given this intermediate training, but the pupils composing it were employed at the regular school work. No other practice was allowed any pupil on any of the figures outside of the time of the regular training periods. At the close of the five weeks period of the training the test series was repeated in exactly the same way as at first and was given to both practice and non-practice groups. This completed the test.

The following table gives the summary of the results of test I, showing the averages of the practice and non-practice groups with respect to speed and accuracy, in both the initial and final test series, their gain in speed and accuracy in the final over the initial test series, and the gain (+) or loss (-) in speed and accuracy of the practice group over the non-practice group.

TEST I

Table 1

Averages

	Initial Test		Final Test	
Group	Accuracy	Speed	Accuracy	Speed
Practice	2.597	78.119	3.298	118.91
Non-Practice	2.627	76.22	3.022	129.512
Gain of each group in final test over initial test.		Practice	0.701	40.791
		Non-Practice	0.395	53.292
Gain of Practice group over Non-Practice group			0.306	-12.501

The most striking feature, perhaps, is the great gain of both groups through the period of incubation. The increase in accuracy for the practice and non-practice groups is about 26.9% and 15% respectively; in speed, 52.2% and 69.9% respectively. Had no control group been used, it would have appeared that the training had resulted in the large increase of both speed and accuracy. Comparison of the two groups shows, however, that the gain of the practiced group in accuracy is almost twice as great, 99 1/3% more, as that of the non-practiced group, while in speed the practiced group falls behind in gain about one-fourth, 25.3%.

TEST II

Test II was conducted with the same pupils as test I. In this test specially printed sheets 6" by 16" were used for the work. About 2,040 small capitals, so arranged that they made neither words nor sentences were printed on each sheet. Thruout this pi, there were scattered about 200 A's. The children were required to mark accurately thru the center as many of these A's as possible, paying due attention to the accuracy of marking. Two days were employed for this test, five minutes each day. The pupils were then divided into two groups. One group was practiced for thirteen days in marking out other letters than the A's. The second group,used as a control group, were not given this training at all. After the training period, both groups were again given the same test as at first, and for the same length of time. The results of this test are given in the following table.

TEST II

Table 2

Averages

	Initial Test		Final Test	
Group	Accuracy	Speed	Accuracy	Speed
Practice	5.958	122.816	5.4788	156.338
Non-Practice	5.919	130.307	5.9077	173.692
Gain of each group in final test over initial test		Practice	-0.4789	33.522
		Non-Practice	-0.109	43.385
Gain of Practiced over Non-Practiced group			-0.4680	-9.863

The results of test II are in part similar to those of test I. The similarity is in the same loss of the practiced group to the non-practiced group in comparative gain of speed. The practiced group gains 27.41 per cent in speed, the non-practiced group, 33.2 per cent. Thus the practiced group falls behind in speed over one-sixth (17.48%). The difference is with respect to accuracy. In test I the practiced group excelled in accuracy. In this test the result is reversed. Both groups, in the final test series, fall behind their mark for the initial test series; the practiced group 8.05 per cent, the non-practiced group only 1.84 per cent. It should be remembered, however, that as has already been explained, the grading for accuracy in this test was for unavoidable reasons rather uncertain and unsatisfactory. Here we may well remark also the unsatisfactory character of per cent comparisons where relatively small numbers are considered. Such comparisons are often misleading. For this reason, care has been taken to give tables to show the exact numbers on which the per cent comparisons are based as well as to permit a more satisfactory notion of first results to be obtained.

But in general, the results of test II show that the practiced group has fallen behind the non-practiced group with regard to gain in both speed and accuracy.

TEST III

Test III was conducted with about 1500 Bloomington school children from the first to the eighth grade inclusive. The test was divided into two parts, IIIa and IIIb, which were carried on at the same time but in different schools. The latter was conducted in the Emerson school, the former in the four other schools carrying on the tests, Washington, Jefferson, Hawthorne, and Irving.

Test IIIa was identical with test I except that four instead of five days each were used for the initial and final tests. Test IIIb was conducted like IIIa as far as method is concerned, but the order of figures was changed. Figure 1[#], that was used for the initial and final tests in IIIa, was made the figure for intermediate training in IIIb, while the five figures, 2, 3, 4, 5, and 6[#], used for training in IIIa, were used in the initial and final tests in IIIb. This constitutes a significant difference in procedure. For while in IIIa the same figure was used five times each, in the initial and final tests of five days, in IIIb a different figure was used on each day of the tests. Therefore, the habit of making each different figure for one day respectively will not be so completely formed as would be the habit of making the one figure for five days. We may expect more or less different results under these conditions. A more complete statement of the method used in test IIIa may be found in the directions to the teachers, reproduced in the appendix, note 2.

[#] - See Appendix, note 1.

The general results of test IIIa are given in the tables 3, 4, 5, and 6. Table 3 shows by grades the daily averages in speed and accuracy. The results for the corresponding days of the initial and final test series are arranged in parallel columns. Table 4 is a summary of table 3. Table 5, compiled from table 3, and arranged in the same manner, shows the gain (+) or loss (-) of both practiced and non-practiced groups in the final series over the initial series, and the comparative gain (+) or loss (-) of the practiced group over the non-practiced group. Table 6 is a summary of table 5.

TABLE 3

Daily Averages of the Grades in Speed and Accuracy

Washington and Jefferson Schools

First Day

Grade	Group	Initial Test Speed	Initial Test Accuracy	Final Test Speed	Final Test Accuracy
I	Practiced	3.681	36.1	5.14	58.3
	Non-Practiced	2.06	20.0	3.88	66.99
II	Practiced	5.4	29.5	6.53	42.0
	Non-Practiced	4.64	31.4	5.04	59.3
III	Practiced	3.47	57.23	5.15	93.76
	Non-Practiced	3.55	52.42	5.03	97.78
IV	Practiced	5.38	55.1	6.54	81.1
	Non-Practiced	5.66	49.33	6.10	96.96
V	Practiced	5.44	73.44	6.92	82.4
	Non-Practiced	5.75	79.1	6.57	117.0
VI	Practiced	6.53	38.85	7.72	142.1
	Non-Practiced	6.23	44.53	7.03	138.86
VII	Practiced	6.84	57.67	8.82	99.0
	Non-Practiced	6.65	55.65	8.30	99.55
VIII	Practiced	7.26	57.84	8.32	121.7
	Non-Practiced	7.00	65.07	7.83	130.3

TABLE 3 (Continued)

Second Day

Grade		Initial Test		Final Test	
		Speed	Accuracy	Speed	Accuracy
I	Practiced	4.59	50.7	4.64	84.5
	Non-Practiced	3.31	45.1	3.69	82.7
II	P	5.57	46.9	6.96	55.2
	N-P	4.95	54.5	5.73	80.41
III	P	4.21	101.09	5.54	128.7
	N-P	3.88	93.8	5.00	112.1
IV	P	5.30	92.1	6.42	101.9
	N-P	5.53	80.5	6.1	107.3
V	P	5.68	111.44	6.72	112.76
	N-P	6.19	106.2	6.62	135.7
VI	P	6.44	76.4	7.92	142.1
	N-P	6.70	65.8	7.37	127.16
VII	P	7.17	79.89	8.62	107.24
	N-P	7.30	65.05	8.00	108.4
VIII	P	7.06	111.03	8.10	150.74
	N-P	6.56	114.03	8.20	140.26

TABLE 3 (Continued)

Third Day

Grade		Initial Test Speed	Initial Test Accuracy	Final Test Speed	Final Test Accuracy
I	P	4.83	55.6	5.5	81.5
	N-P	3.64	53.2	3.74	79.5
II	P	5.83	46.0	6.30	54.61
	N-P	5.37	64.05	5.35	71.3
III	P	4.77	103.6	4.82	128.9
	N-P	4.45	110.5	4.97	106.6
IV	P	4.86	112.75	6.16	122.6
	N-P	4.82	95.5	6.54	111.1
V	P	5.27	127.8	7.18	92.4
	N-P	6.25	126.2	7.00	110.95
VI	P	6.75	112.55	7.8	148.8
	N-P	6.49	96.5	7.42	138.65
VII	P	6.92	83.2	8.50	115.5
	N-P	7.00	78.94	7.95	120.5
VIII	P	6.74	137.6	8.32	145.03
	N-P	6.63	134.26	7.73	142.8

TABLE 3 (Continued)

Fourth Day

Grade		Initial Test		Final Test	
		Speed	Accuracy	Speed	Accuracy
I	P	4.06	52.5	4.75	82.56
	N-P	3.66	55.55	3.63	90.9
II	P	6.00	62.41	6.41	68.41
	N-P	4.39	91.05	4.55	112.32
III	P	4.90	96.0	5.32	127.0
	N-P	4.2	97.08	5.25	107.0
IV	P	4.97	134.9	7.77	89.84
	N-P	5.04	109.44	7.12	86.6
V	P	5.63	134.23	7.55	95.5
	N-P	6.2	144.05	6.92	112.5
VI	P	6.69	117.3	8.05	137.6
	N-P	6.45	100.04	7.15	126.4
VII	P	7.19	99.00	8.59	116.9
	N-P	7.06	85.75	7.87	126.63
VIII	P	6.94	136.8	8.03	155.63
	N-P	6.47	132.5	8,19	147.55

TABLE 4

Summary of Table 3

All Grades		First Day			
		Initial Test		Final Test	
		Speed	Accuracy	Speed	Accuracy
	P	5.499	51.98	6.933	91.95
	N-P	5.332	51.84	6.299	104.10
		Second Day			
	P	5.748	86.12	7.043	110.66
	N-P	5.606	81.20	6.847	114.36
		Third Day			
	P	5.760	98.81	6.796	113.19
	N-P	5.654	99.36	6.511	113.87
		Fourth Day			
	P	5.859	108.28	6.963	113.27
	N-P	5.663	104.98	6.657	111.74

In examining the numerical results, the most striking feature is the effect on the non-practiced group of the period of incubation between the initial test series and the repetition of that test in the final series. A comparison of the results for the two series shows that this period of rest for the non-practiced group has increased their accuracy from an average of 5.56 in the first test series to 6.57 in the final series, and their speed from 83.02 in the first test series to 110.95 in the final series.

The practiced group durińg this period of incubation were given training. Their increase in the final test series over the initial test series is in accuracy from 5.72 to 6.90, and in speed from 85.13 to 107.37.

Both groups show a large increase in both speed and accuracy. Had no control group been used, all the increase for the practiced group would naturally have been attributed to the effect of the training. What we find is, that with respect to the last day of the initial test series and the first day of the final test series the practiced group gains in accuracy over the non-practiced group, 0.438, or about 68% more than was gained by the non-practiced group. While the practiced group gained in accuracy, there was a decided drop in speed which falls off from 108.28 to 91.95. The non-practiced group maintain practically the same speed for the two days, 104.91, and 104.98 respectively. The practiced group, then, has dropped behind in speed but gained in accuracy.

With respect to the same point as shown by different grades, the following table will give a more accurate estimate.

TABLE 5

Washington and Jefferson Schools

Gain of the Practiced and Non-Practiced Groups in the Final Test Over the Initial Test, and the Comparative Gain (+) or Loss (-) of the Practiced over the Non-Practiced Group.

Grade		First Day		Second Day	
		Accuracy	Speed	Accuracy	Speed
I	P	1.459	22.2	0.05	33.8
	N-P	1.82	46.94	0.38	37.6
		-0.361	-24.74	-0.33	-3.8
II	P	1.13	12.5	1.39	8.3
	N-P	0.40	27.9	0.78	25.91
		0.73	-15.4	0.61	-17.61
III	P	1.68	36.53	1.33	27.61
	N-P	1.48	45.36	1.12	18.3
		0.20	-8.83	0.21	9.31
IV	P	1.16	26.0	1.12	9.8
	N-P	0.44	47.63	0.67	26.8
		0.76	-21.63	0.45	-17.0
V	P	1.48	8.96	1.04	1.32
	N-P	0.82	37.9	0.43	29.5
		0.66	-28.94	0.61	-28.18
VI	P	1.19	103.25	1.48	65.7
	N-P	0.80	94.33	0.67	61.36
		0.39	8.92	0.81	4.34
VII	P	1.98	41.33	1.45	27.35
	N-P	1.65	43.90	0.70	43.35
		0.33	-2.47	0.75	-16.00
VIII	P	1.06	63.86	1.04	39.71
	N-P	0.83	65.27	1.64	26.23
		0.23	-1.41	-0.60	13.48

TABLE 5 (Continued)

Grade		Third Day Accuracy	Third Day Speed	Fourth Day Accuracy	Fourth Day Speed
I	P	0.67	25.9	0.684	30.06
	N-P	0.10	26.3	-0.03	35.36
		0.57	-0.4	0.714	-5.30
II	P	0.47	8.61	1.41	6.00
	N-P	-0.02	7.25	0.16	21.27
		0.49	1.36	1.25	-15.27
III	P	0.05	25.3	0.42	31.00
	N-P	0.52	-3.9	1.05	9.2
		-0.47	29.2	-0.63	21.8
IV	P	1.30	9.85	2.80	-45.06
	N-P	1.72	15.6	2.08	-22.84
		-0.42	-5.75	0.72	-22.22
V	P	1.91	-35.4	1.91	-38.73
	N-P	0.75	-15.25	0.72	-31.55
		1.16	-20.15	1.19	-7.18
VI	P	1.05	36.25	1.36	20.3
	N-P	0.93	42.15	0.75	26.36
		0.12	-5.90	0.61	-6.06
VII	P	1.85	32.3	1.40	17.9
	N-P	0.95	41.56	0.81	40.88
		0.90	-9.26	0.59	-22.98
VIII	P	1.58	7.43	1.09	18.83
	N-P	1.13	8.54	1.72	15.05
		0.45	-1.11	-0.63	3.78

TABLE 6

Summary of Table 5

		First Day		Second Day	
		Accuracy	Speed	Accuracy	Speed
All Grades	P	1.434	39.97	1.265	24.54
	N-P	0.967	52.26	1.241	33.16
		0.467	-12.29	0.024	-8.62

	Third Day		Fourth Day	
	Accuracy	Speed	Accuracy	Speed
P	1.036	14.38	1.104	4.99
N-P	0.857	14.51	0.994	6.76
	0.179	-0.13	0.11	-2.23

TABLE 7

Averages

Grade	Group	Last Day of the Initial Test Series Accuracy	Last Day of the Initial Test Series Speed	First day of the Final Test Series Accuracy	First day of the Final Test Series Speed
I	P	4.06	52.5	5.14	58.8
	N-P	3.66	55.55	3.88	66.94
II	P	6.00	62.41	6.53	42.0
	N-P	4.39	91.05	5.04	59.3
III	P	4.90	96.00	5.15	93.76
	N-P	4.20	97.08	5.03	97.78
IV	P	4.97	134.9	6.54	81.1
	N-P	5.07	109.44	6.10	96.96
V	P	5.636	134.23	6.92	82.4
	N-P	6.2	144.05	6.57	117.0
VI	P	6.69	117.3	7.72	142.1
	N-P	6.45	100.04	7.03	138.86
VII	P	7.19	99.00	8.82	99.0
	N-P	7.06	85.75	8.30	99.55
VIII	P	6.94	136.8	8.32	121.7
	N-P	6.47	132.5	7.83	130.3

TABLE 7 (Continued)

		Gain of the Groups in the First Day of the Final Test Series over the Last Day of the Initial Test Series		Gain of the Practiced Group over the Non-Practiced Group	
Grade	Group	Accuracy	Speed	Accuracy	Speed
I	P	1.074	6.3		
	N-P	0.22	11.4	0.854	-5.1
II	P	0.53	-20.41		
	N-P	0.65	-41.75	-0.12	21.34
III	P	0.25	-2.24		
	N-P	0.83	0.7	0.58	2.94
IV	P	1.57	-53.8		
	N-P	1.06	12.48	0.51	-66.28
V	P	1.18	-51.8		
	N-P	0.55	-27.05	0.63	-24.75
VI	P	1.03	24.8		
	N-P	0.58	38.82	0.45	-14.02
VII	P	1.63	0.0		
	N-P	1.24	13.80	0.39	-13.80
VIII	P	1.38	-15.1		
	N-P	1.36	-2.2	0.02	-12.9

The table shows that the third grade practiced group has fallen behind the non-practiced group in point of gain of both speed and accuracy. In the second grade, the practiced group has fallen behind in gain of accuracy but shows a large increase over the non-practiced group in gain of speed. In all the other grades there has been the characteristic result, namely an increase in the gain of accuracy of the practiced over the non-practiced group, with the reverse true with respect to speed.

Another way to estimate the results of the test is to analyse the work by days, comparing each of the four days in the initial test with its corresponding day of the final test. Table 3 is arranged to show by grades the general averages of speed and accuracy. The averages for the corresponding days are arranged in parallel columns, and show the results for each grade. Table 4, arranged in the same way, gives the totals for the eight days. Table 5 shows by grades the differences between the corresponding days of the initial and final tests, and expresses the gain ( ) or loss (-) of the practiced group over the non-practiced group. In grade 1 only is there any consistent reversal of the indications that the practiced group gains in accuracy and loses in speed with respect to the non-practiced group. In that grade for the first two days, the practiced group falls behind in both speed and accuracy.

But owing to the fact that some of the youngest children apparently did not understand what was required of them; that irregular attendance thru the months of January and February made the data very incomplete; and that this irregularity

of attendance made the two groups very unequal numerically, the results from grade 1 are of doubtful value. Therefore, a general summary has been made exclusive of that grade. In the latter part of the week the first grade seems to fall in line with the general tendency to gain in accuracy and lose in speed. In the other grades, by table 1, we find that in twenty-three cases of the twenty-eight the practiced group gains in accuracy over the non-practiced group. In twenty cases out of the twenty-eight the practiced group loses in speed to the non-practiced group.

A summary of table 5 shows for the four days of the initial test compared respectively with the four days of the final test for the gain ( ) or loss (-) of the practiced over the non-practiced group, the following,--

Day	Accuracy	Speed
First	0.46	-9.98
Second	0.41	-7.38
Third	0.23	-0.62
Fourth	0.17	-6.88

If we combine the four days of the initial test and compare them with the four of the final test, we find the results to be,--

Averages

	Initial Test		Final Test	
	Accuracy	Speed	Accuracy	Speed
P	5.72	85.13	6.90	107.37
N-P	5.56	83.02	6.57	110.95

Gain (+) or Loss (-) of the Practiced over the Non-Practiced Grou

Accuracy	Speed
0.17	-5.69

The result is thus indicative of an increase of accuracy and loss of speed for the practiced group in comparison with the non-practiced group.

TEST IIIb

The next test, IIIb, conducted with about 225 school children, has been described as to method[1]. The initial test, as explained, was that of making, for five minutes on the first day, Figure 2[2]; on the second day the figure 3; on the third day the figure 4; on the fourth day the figure 5; on the fifth day the figure 6. The training was practiced for five minutes each day for twenty-five days, or five school weeks, in making figure 1. The results are given in tables 8 and 9.

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1 - See appendix, Directions for the experiment in the Emerson School.

2 - See appendix for these figures.

TABLE VIII

Averages

	Initial Test		Final Test		Figure
	Accuracy	Speed	Accuracy	Speed	
Group		First Day			
P	4.038	30.38	4.904	57.11	2
N-P	3.475	26.46	4.485	53.72	
		Second Day			
P	4.065	51.22	4.536	71.16	3
N-P	4.091	50.16	5.071	70.17	
		Third Day			
P	4.27	109.23	4.626	118.04	4
N-P	4.08	95.59	4.36	107.729	
		Fourth Day			
P	4.746	80.55	5.644	77.34	5
N-P	4.609	66.66	5.138	70.53	
		Fifth Day			
P	3.926	41.315	4.590	49.357	6
N-P	3.932	36.86	4.147	42.95	

TABLE IX

	Gain of each Group in the Final Test over the Initial Test			Gain (+) or Loss (-) of the Practiced Group over the Non-Practiced Group	
Group	Accuracy	Speed	Figure	Accuracy	Speed
		First Day			
P	0.866	26.73	2		
N-P	1.01	27.26		-0.144	-0.53
		Second Day			
P	0.471	18.94	3		
N-P	0.98	20.01		-0.509	-1.07
		Third Day			
P	0.356	8.81	4		
N-P	0.28	12.139		0.076	-3.329
		Fourth Day			
P	0.898	-3.21	5		
N-P	0.529	3.87		0.371	-7.08
		Fifth Day			
P	0.664	8.042	6		
N-P	0.215	6.09		0.449	1.952

In Table 9 it is evident that the difference in speed between the two groups is rather insignificant, falling usually within the limit of the probable error. The only case where there is a probability of the indication being significant with respect to speed is on the fourth day, figure 5.

The results by days appear in the table to show for the figure 2 a loss in accuracy for the practiced group, and no difference in gain of speed; for the figure 3 a loss in accuracy and no difference in gain of speed; for the figure 4 a very small gain in accuracy, falling almost within the limit of probable error, for the practiced group, with practically no difference in gain of speed; for the figure 5 a gain in accuracy and loss in speed; for the figure 6 a gain in accuracy with no difference in gain of speed.[1]

From the first day, however, the pupils of the practiced group gradually increased their accuracy until, at the end of the third day, the results indicate the same as the other grades: that the practiced group increase in accuracy over the non-practiced group, and lose in speed.

1 - It is desirable to bear in mind that the numerical differences in many cases are slight. Moreover, only about one-half of the very extensive and voluminous data of the last experiments has been used in this preliminary report. The complete results may modify largely those stated in this thesis.

GENERAL CONCLUSIONS

An analysis of the foregoing discussion seems to warrant us in making the following conclusions.

1 - As in the case of previous experimental investigation, it is likewise true in this particular investigation that there are evidences of transfer effects from one activity to another closely allied to it, both positive and negative. That these transfer effects are no more pronounced is probably due in part to the fact that the habits under investigation are complex, and that in them are mutually inhibiting tendencies, which result in a neutralization of single transfer effects. The complexity of these habits might well be the subject of further analysis. That such a complexity exists is shown particularly in the results of test IIIb, carried on at the Emerson School. Table 9 indicates that during the first two days of the test series there is an inhibition of both speed and accuracy. The third day showed a practically neutral result, while on the fourth and fifth days there is a decided evidence of a positive transfer in accuracy. Such a result as this, if it is significant, can be accounted for only on the theory of mutually inhibiting tendencies in a complex habit formation. It is probably true that in the second test series in this part of the experiment there existed in the subjects a distraction of attention from the marking of the test figures because of their unlikeness to the figure that had been employed during the five

weeks of practice. We may assume that as the test progressed this inhibition in attention was overcome and that the factors that made for improvement obtained the ascendency.

In this connection it is further to be noted that the interference effect is greater on the second day of the test series than on the first day. This circumstance may seem to conflict with the explanation just offered, since it might be expected that there would be a continuous decrease in the inhibitory effects from the first day to the final day of the tests. The seeming discrepancy, however, is easily explained when we notice that the figure employed on the first day's tests is a modified form of figure 1 used in the practice series. The greater similarity will, therefore, account for the diminution of inhibitory effects due to interference in attention. Indeed this result is an admirable illustration of the complexity of what may seem at first to be a simple habit.

2 - In the various tests, with the exception of test 2, in which the materials used were quite different from those employed in the remainder of the experiments, there is a substantial agreement in results. In both the practiced and the non-practiced groups, there is a large increase both in speed and accuracy in the final over the initial test. But the comparative gain in accuracy for the practiced group exceeds in general that of the non-practiced group. The transfer in accuracy and not in speed may be explained as due to several causes. One of these is the fact that thruout the test and

practice series there was a constant insistence on the part of the teachers of the necessity for accuracy. In the practiced group, this insistence covered a period of much greater time than that consumed by the non-practiced group. Hence, in the former group, accuracy had a greater chance to be emphasized as an ideal. It may be objected that the ideal of speed was also insited on to an extent and that in the second test, altho the ideal of accuracy in marking out the letters was upheld, no such transfer effects resulted.

This objection brings us to a second point in our consideration of the cause of this positive transfer in accuracy, namely, that the materials used in all these tests except the second were of such a nature as to call forth the attentive attitude on the part of the pupils in drawing them. In other words, thought had to be given in their construction. The process could not be reduced to that of mere unthinking habit, as in the case of test 2, in the marking out of capitals. When we compare the results of tests I and IIIa with those of IIIb, we find that the average gain in accuracy is much greater in the former than in the latter. This may be explained as due to the fact that in tests I and IIIa the materials employed in the practice series were of such a nature that habit formation was by no means perfected, while in test IIIb the habit formed in the practice series was relatively well perfected. This would result in less thought being expended in the construction of the single figure in the practice series in test IIIb

than in the construction of the five complicated figures in the practice series in tests I and IIIa.

In the test series in I and IIIa, it is to be noted that the transfer in accuracy is greater on the first day than on any of the following, and that there is a gradual decrease in this transfer day by day. This is exactly the reverse of what we find in test IIIb, as has already been pointed out. The explanation seems fairly simple. In the practice series in tests I and IIIa, there were slight opportunities of perfecting a habit. In the test series, on the other hand, such a habit formation was much more easy. The gradual falling off in transfer effect in accuracy is an indication that the habit is approaching perfection; that is, that it is becoming less a matter of thought and more of habituation.In test IIIb we have an exact reverse of these conditions, and we would expect the exact reverse in numerical results.

3 - There seems to be, on the whole, an inverse relation between accuracy and speed, altho the results here need further working out before any definite statement of correlation between these two factors can be made. The non-practiced group, unhampered by any clear notion of accuracy acquired in the practice series, approached the final test without definite ideas of accuracy. In speed, they thus readily surpassed the practiced group. As would be expected, we find the discrepancy between the practiced and non-practiced groups the most pronounced on the first day of the final test series. On the first day, factors that inhibited the speed in the

practiced group would be particularly prominent. The practiced group, paying more attention to accuracy, dropped behind the non-practiced group in the gain of speed. The practice series has developed in them a new set of motor coordinations. These new elements of the practice series interfere with the final test series. For example, in test IIIa, the initial test series was to make, on each of the four days of this test, figure 1. In constructing this figure, the pupil observed the corners and center of the square in which the figure was inscribed in order to place this figure accurately. Now in the making of the five geometrical figures, constituting the training series, to place the figures accurately, the pupil must observe in making figure 2 the middle points of the sides of the square and a reversely curved line; figure 3, the middle points of the sides of the square and a straight line; figure 4, the center of the square and the trisection of its sides; figure 5, a trisection of the sides of the square and the union of straight lines; figure 6, the trisection of the dimensions of the square to place a square within a square, and the joining of the corresponding corners of these squares by a straight line. All these new factors have been introduced by the practice series and have been made prominent by their repetition thruout the series. We should expect these factors, many of which are not at all essential in making figure 1 of the test series, to interfere with, and even to inhibit to a certain extent, the making of figure 1 in the final test series. For upon changing

from the practice series, the pupils must divest themselves of these unessential factors acquired in the practice series before they can make most accurately and rapidly the final test series. The inhibitive effect of these new factors, which were introduced and made effective in function by the training series, should be, as already suggested, most apparent in the first day of the final test series, and then become less apparent for each succeeding day of the test series. For as the practiced group divest themselves of the unessential factors and make use of the essential factors, their greater habituation to the work should enable them to gain on the non-practiced group in speed as well as accuracy. A comparison of the speeds of the two groups for the four days of the final test shows this to be true.

Final Test Series

Speed of the Two Groups

	First Day	Second Day	Third Day	Fourth Day
P	91.95	110.66	113.19	113.27
N-P	104.10	114.36	113.87	111.74

It is seen by these results that the practiced group are much behind at the outset but rapidly gain until at the end of the third day they are equal, and on the fourth day, slightly ahead of the non-practiced group in speed, and on this fourth day still average 0.306 higher in accuracy. This statement may be objected to as contradicting the general

statement that the practiced group has gained in accuracy and lost in speed. There is no contradiction, however, for the general statement is based on the totals which are in favor of the non-practiced group with respect to speed. The oher statement is based on the relative increase of speed by days for the four days of the final test series.

4 - One of the most striking results of the experiment under discussion is found in the fact that both for the practiced and non-practiced groups there is an absolute increase in both speed and accuracy in the final test over the initial test. This result is perhaps due in part to the effect of habituation developed in the first test, on the second test. It may be due in part also to incubation. The fact that incubation improves a habit has been brought out by several experimenters. Book[1] concludes that this is to be explained on the ground that the unfavorable elements of the habit formation are forgotten during the period of rest. That direct habit formation and incubation has functioned to increase both speed and accuracy is seen in the large increase in these respects by the non-practiced groups in the final tests after the period of incubation over their speed and accuracy in the initial test. The same is true of the practiced groups, but we have there the added fact of training to modify the result.

Now if in addition to incubation habituation has had a part in determining he result, we should be able to prove that

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1 - Book, W.F. The Psychology of Skill with Special Reference to its acquisition in typewriting. (University of Montana, Publications in Psychology, Vol. 1.)

hypothesis pretty definitely. For according to that hypothesis, the greater the habituation developed in the initial test series, the greater should be the gain in the final test series, the less the habituation developed in the initial test series, the less should be the gain in the final test series. Now experiments IIIa and IIIb clearly fulfill these conditions of greater and less habituation. For in IIIa, figure 1 was made for four successive days so that the habit of making that figure would, in this initial test, be fairly well formed. In test IIIb, each different figure used in the initial test series was used for but one day, so that the habit of making that figure would be very incompletely formed. So to determine the correctness of our inference, we need only to compare the gain of each group in the final test series over the initial test series in test IIIa, where the habit was most completely formed, with the gain of the corresponding groups in test IIIb, where the habit was but imperfectly formed. The following table is arranged to show this comparison.

Amount of Gain in the Final Test Series over the Initial Test Series,

	In Test IIIa Habit Well Formed		In Test IIIb Habit Incompletely Formed	
By Practiced Groups	Accuracy	Speed	Accuracy	Speed
First Day	1.434	39.97	0.866	26.73
Second Day	1.265	24.54	0.471	18.94
Third Day	1.036	14.38	0.356	8.81
Fourth Day	1.104	4.99	0.898	-3.21
By the Non-Practiced Groups				
First Day	0.967	52.26	1.01	27.26
Second Day	1.241	33.16	0.980	20.01
Third Day	0.857	14.51	0.28	12.139
Fourth Day	0.994	6.76	0.529	3.87

The larger gain in absolute speed and accuracy by each group in the final test series of test IIIa, in which the habit was more completely formed than the gain by each group in the final test series of IIIb, in which the habit was very incompletely formed, is very pronounced.

Therefore, the explanation offered at the outset of (4), of the fact that both for the practiced and non-practiced groups, there is an absolute increase in both speed and accuracy in the final test series over that of the initial test series, is due in part to the effect of incubation and also in part to the effect of habituation, proves to be correct.

APPENDIX

Note 1: The following are the figures to which reference has been made in this discussion:

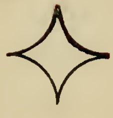
Figure 1 ....


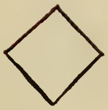
Figure 2 ....


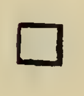
Figure 3 ....


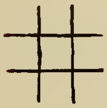
Figure 4 ....


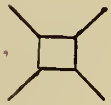
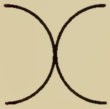
Figure 5 ....


Figure 6 ....


Note 2: The following is an exact reproduction of the instructions given the teachers for conducting experiments I, IIIa, and IIIb:

I The pupil before the beginning of each experiment should be provided with a properly sharpened pencil and with one sheet of the specially ruled paper, on the back of which, in the upper left hand corner he is to write first, his name, then the grade, and then the date. This must be done in every instance.

II The pupils are to be told that they are to make the letter or figure accurately and at the same time rapidly; that the pupils that receive the highest grades will be those who make the most figures in the time given provided that they make them neatly and carefully; but that a pupil that does careless work will not be given a high mark simply because he

makes many figures. The fact that the pupil is to work both rapidly and accurately should be emphasized often during the progress of the test and practice experiments (during the entire seven weeks).

III After these preliminaries, at a given signal, the pupils are to begin to write and to continue for exactly five minutes. At the signal stop, they must at once discontinue their work. The papers are then to be collected and the number of figures made on each paper recorded. As often as possible, at least once a week, the results of the test is to be given out. The names of the few highest (who at the same time have written neat and careful papers) are to be written on the board with the score that they have made; also the highest pupil in each room is to be compared with the highest in other rooms of the building. This is to stimulate interest and keep the pupils up to a maximal effort thruout the test.

IV FOR THE FIRST "TEST EXPERIMENT",

in all the schools except Emerson, the pupils are to be tested during the five days of the first week, each day, in making the letter X (fig. 1) in the squares of specially provided paper. During the first week in the Emerson school, the pupils are to make, on the first day, figure 2, on the second day figure 3, on the third day figure 4, on the fourth day figure 5, and on the fifth day figure 6.

V At the end of he first week's tests in each school the pupils are to be divided into two approximately equal

groups for the "Practice Experiment". The first group is to be practiced for five weeks in the manner described below; the second group is to have no practice during the five weeks, but is to engage in the ordinary school occupation during the period at which the first group is being practiced. The practiced group, in all but the Emerson School, during the five weeks, is to draw on the first day of each week figure 2, on the second day figure 3, on the third day figure 4, on the fourth day figure 5, on the fifth day figure 6. This order is to be repeated each week for five weeks.

In the Emerson School for five weeks (25 days) the pupils are to write each day the letter X. During the practice period the same method is to be employed as set forth under I and II. The test in every case is for five minutes exactly.

VI At the end of the five weeks practice, both groups, the practiced and the non-practiced, are to be again combined for the second test experiment, and all to be tested as in the first test experiment; namely, in all but the Emerson School, the pupils are to be tested in making figure 1 on each of the five school days. In the Emerson School, the pupils are to make figure 2 on the first day; figure 3 on the second day, and so on thru the entire five days.

VII The experiment should be performed at a given period each day thruout the entire test of seven weeks. It is not particularly important when this period is, provided that it is uniform for each room or that it comes at a time when the

pupils are not fatigued and when there are no unusual distractions. It should not come immediately before recess or before the close of school. Probably the best time is early in the forenoon. If any of the pupils do not try, their work should be thrown out. The pupils are, under no circumstances, to practice the test at any other time in the school or out than that set aside particularly for it.

N.B. - These notes have been reproduced as originally written for the teachers, except that, owing to the way in which they have been referred to in this thesis, the number of the figures has been changed. They have been changed in this order:

Fig. 1 to Fig. 2
Fig. 2 to Fig. 3
Fig. 3 to Fig. 4
Fig. 4 to Fig. 5
Fig. 5 to Fig. 6
Fig. 6 to Fig. 1.

It is in conformity with this latter order that they are numbered in Note 1 on this Appendix.

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